IMAQ™

IMAQ PCI-1428
User Manual

High-Quality Camera Link Image Acquisition Device for PCI

NATIONAL INSTRUMENTS™

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For further support information, see the *Technical Support Resources* appendix. To comment on the documentation, send e-mail to techpubs@ni.com.

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Compliance

FCC/Canada Radio Frequency Interference Compliance*

Determining FCC Class

The Federal Communications Commission (FCC) has rules to protect wireless communications from interference. The FCC places digital electronics into two classes. These classes are known as Class A (for use in industrial-commercial locations only) or Class B (for use in residential or commercial locations). Depending on where it is operated, this product could be subject to restrictions in the FCC rules. (In Canada, the Department of Communications (DOC), of Industry Canada, regulates wireless interference in much the same way.)

Digital electronics emit weak signals during normal operation that can affect radio, television, or other wireless products. By examining the product you purchased, you can determine the FCC Class and therefore which of the two FCC/DOC Warnings apply in the following sections. (Some products may not be labeled at all for FCC; if so, the reader should then assume these are Class A devices.)

FCC Class A products only display a simple warning statement of one paragraph in length regarding interference and undesired operation. Most of our products are FCC Class A. The FCC rules have restrictions regarding the locations where FCC Class A products can be operated.

FCC Class B products display either a FCC ID code, starting with the letters **EXN**, or the FCC Class B compliance mark that appears as shown here on the right.

Consult the FCC Web site `http://www.fcc.gov` for more information.

FCC/DOC Warnings

This equipment generates and uses radio frequency energy and, if not installed and used in strict accordance with the instructions in this manual and the CE Mark Declaration of Conformity**, may cause interference to radio and television reception. Classification requirements are the same for the Federal Communications Commission (FCC) and the Canadian Department of Communications (DOC).

Changes or modifications not expressly approved by National Instruments could void the user's authority to operate the equipment under the FCC Rules.

Class A

Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Canadian Department of Communications

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

Class B

Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Canadian Department of Communications

This Class B digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe B respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

European Union - Compliance to EEC Directives

Readers in the EU/EEC/EEA must refer to the Manufacturer's Declaration of Conformity (DoC) for information** pertaining to the CE Mark compliance scheme. The Manufacturer includes a DoC for most every hardware product except for those bought for OEMs, if also available from an original manufacturer that also markets in the EU, or where compliance is not required as for electrically benign apparatus or cables.

* Certain exemptions may apply in the USA, see FCC Rules §15.103 **Exempted devices**, and §15.105(c). Also available in sections of CFR 47.

** The CE Mark Declaration of Conformity will contain important supplementary information and instructions for the user or installer.

Conventions

This manual uses the following conventions:

<>	Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, DBIO<3..0>.
»	The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.
	This icon denotes a note, which alerts you to important information.
	This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.
bold	Bold text denotes items that you must select or click on in the software, such as menu items and dialog-box options. Bold text also denotes parameter names.
italic	Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text that is a placeholder for a word or value that you must supply.
`monospace`	Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames and extensions, and code excerpts.

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1 Introduction

This chapter provides an overview of the PCI-1428 image acquisition device, the Camera Link standard, Camera Link/PCI-1428 interfacing guidelines, and your software programming choices.

About the IMAQ PCI-1428

The PCI-1428 is a highly flexible IMAQ device that supports a diverse range of Camera Link-compatible cameras from various camera companies. The PCI-1428 acquires digital images in real time and stores the images in onboard frame memory or transfers them directly to system memory. Featuring a high-speed data flow path, the PCI-1428 is ideal for both industrial and scientific environments.

The PCI-1428 is easy to install and configure. It ships with NI-IMAQ, the National Instruments complete IMAQ driver software you can use to directly control the PCI-1428 and other National Instruments IMAQ hardware products. With NI-IMAQ, you can quickly and easily start your applications without having to program the device at the register level.

The PCI-1428 supports the Camera Link Base configuration, and the VHDCI 68-pin connector provides access to the 8-bit × 4 mode of the Camera Link Medium configuration. For further configuration information, see the *Camera Link and PCI-1428* section in Chapter 3, *Hardware Overview*.

The VHDCI 68-pin connector has four external input/output (I/O) lines you can use as triggers or as high-speed digital I/O lines.

Note To use the trigger lines as digital I/O lines, go to the LabVIEW palette, and select **Motion & Vision»Image Acquisition»Signal I/O VIs**.

For more advanced digital or analog system triggering or digital I/O lines, you can use the PCI-1428 and NI-IMAQ with the National Instruments data acquisition (DAQ) or motion control product lines.

Easily synchronizing several functions to a common trigger or timing event is a common challenge with image acquisition devices. The PCI-1428 uses the Real-Time System Integration (RTSI) bus to solve this problem. The RTSI bus uses National Instruments RTSI bus interface and ribbon cable to route additional timing and trigger signals between the PCI-1428 and up to four National Instruments DAQ, motion control, or IMAQ devices. The RTSI bus can even synchronize multiple IMAQ hardware captures.

Detailed specifications of the PCI-1428 are in Appendix A, *Specifications*.

Camera Link

This section provides a brief overview of the Camera Link standard. For more detailed information about Camera Link specifications, reference the *Specifications of the Camera Link Interface Standard for Digital Cameras and Frame Grabbers* manual. This manual is available on several Web sites, including the Automated Imaging Association site at `machinevisiononline.org`.

Overview

Developed by a consortium of camera and frame grabber manufacturers, Camera Link is a standard for interfacing digital cameras with image acquisition devices. Camera Link simplifies connectivity between the image acquisition device and the camera by defining a single standard connector for both. This standard ensures compatibility of devices bearing the Camera Link logo.

The basis for the Camera Link standard is the National Semiconductor Channel Link chipset, a data transmission method consisting of a general-purpose transmitter/receiver pair. The Channel Link driver takes 28 bits of parallel digital data and a clock and serializes the stream to four LVDS (EIA-644) data streams and an LVDS clock, providing high-speed data transmission across 10 wires and over distances of up to 10 m.

Interfacing with the PCI-1428

The Camera Link standard defines physical connections between image acquisition devices and Camera Link cameras, and it allows for flexibility of image format and data transfer protocols. The camera manufacturer defines image parameters, such as image resolution and the number of bits per pixel. Camera control parameters, such as frame-on-demand and exposure control signals, are also defined by the camera manufacturer.

These variable parameters are defined on a per-camera basis in a camera file (`camera_model.icd`) supplied by National Instruments. The NI-IMAQ driver software uses the information in this camera file to program the PCI-1428 to acquire images from a specific camera. Without this camera file, the driver does not have the information necessary to configure the PCI-1428 for acquisition.

Measurement & Automation Explorer (MAX), the National Instruments configuration utility, provides a simple interface for associating a camera file with the PCI-1428. Use the following guidelines to access the camera file in MAX:

1. Launch MAX, and expand the **Devices and Interfaces** branch of the configuration tree.
2. Expand the **IMAQ PCI-1428** branch.
3. Right-click **Channel 0**, and select **Camera**.
4. Select your camera from the pop-up menu. If your camera is not in the pop-up menu, verify that the camera file is installed in the `NI-IMAQ/Data` directory.

Many camera files are installed on your computer when you install NI-IMAQ, and many more are available for download from the National Instruments Camera Advisor at `ni.com\camera`. When installing new camera files, save them to the `Data` folder located at `Program Files\National Instruments\NI-IMAQ\Data`.

Contact National Instruments technical support to request camera files not available in the Camera Advisor. See Appendix C, *Technical Support Resources*, for information on National Instruments technical support.

Software Programming Choices

Use NI-IMAQ, the National Instruments image acquisition driver software, to program your IMAQ device to acquire, display, and save images. You can use NI-IMAQ with other National Instruments software for a complete image acquisition and analysis solution, as shown in Figure 1-1.

NI-IMAQ works with LabVIEW, LabWindows/CVI, Visual C++, and Visual Basic. National Instruments IMAQ Vision adds powerful image processing and analysis to these programming environments. You can also use IMAQ Vision Builder to quickly and easily prototype your IMAQ image analysis applications.

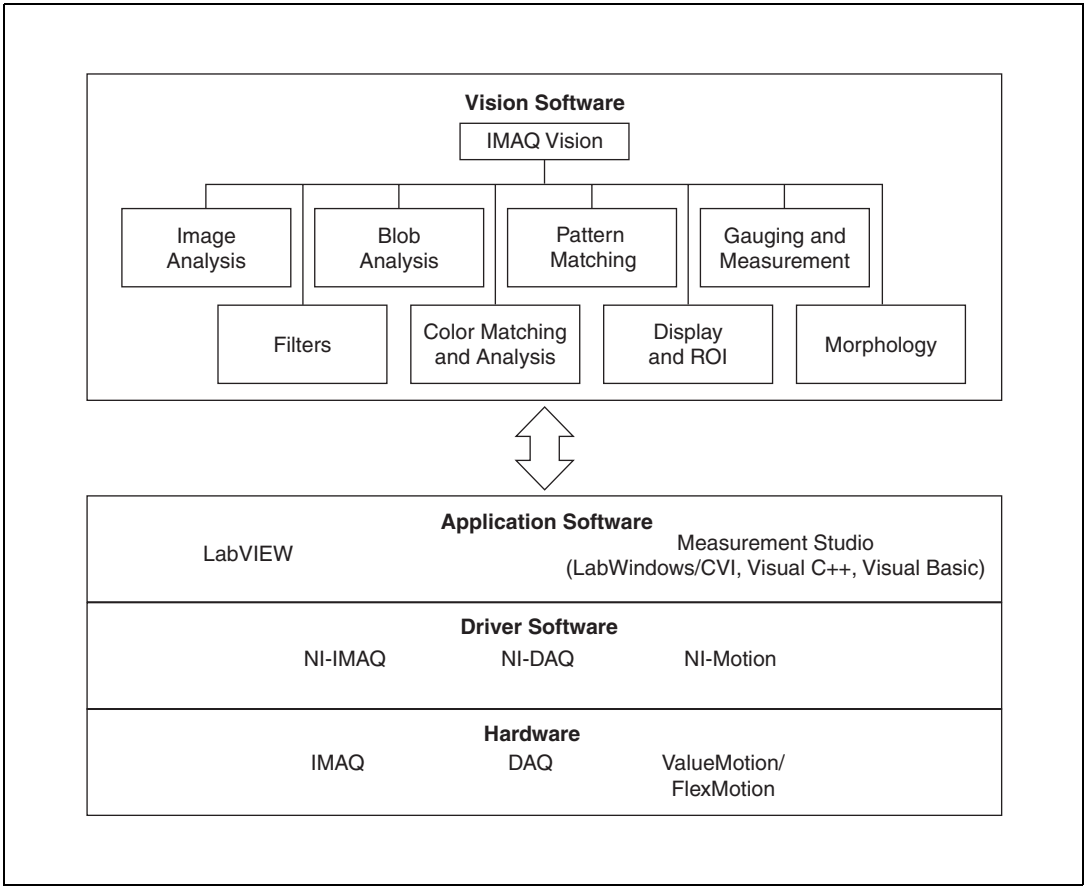


Figure 1-1. The Relationship between the Programming Environment, NI-IMAQ, and Hardware

NI-IMAQ Driver Software

The NI-IMAQ driver software is included with your IMAQ device. NI-IMAQ has an extensive library of functions you can call from your application programming environment. These functions include routines for video configuration, image acquisition (continuous and single-shot), memory buffer allocation, trigger control, and device configuration, as shown in Figure 1-2.

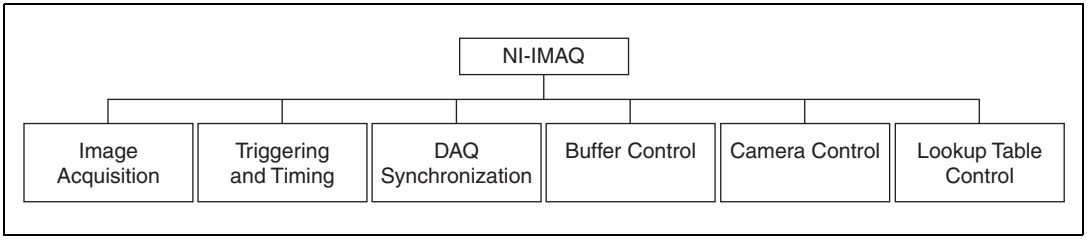


Figure 1-2. NI-IMAQ Functions

The NI-IMAQ driver software performs all functions required for acquiring and saving images, but it does not perform any image analysis. For image analysis functionality, refer to the *National Instruments IMAQ Vision* section in this chapter.

For maximum flexibility and performance, NI-IMAQ features both high-level and low-level functions. Examples of high-level functions include the functions to acquire images in single-shot or continuous mode. An example of a low-level function is configuring an image sequence, since it requires advanced understanding of the IMAQ device and image acquisition.

NI-IMAQ internally resolves many of the complex issues between the computer and the IMAQ device, such as programming interrupts and DMA controllers.

NI-IMAQ is also the interface path between LabVIEW, LabWindows/CVI, or a text-based programming environment and your IMAQ device. The NI-IMAQ software kit includes a series of libraries for image acquisition for LabVIEW and Measurement Studio, which contains libraries for LabWindows/CVI, Visual C++, and Visual Basic.

National Instruments IMAQ Vision

IMAQ Vision is an image acquisition, processing, and analysis library of more than 200 functions for grayscale, color, and binary image display, image processing, pattern matching, shape matching, blob analysis, gauging, and measurement.

For unique image processing, you can use IMAQ Vision functions individually or in combination. With IMAQ Vision you can acquire, display, manipulate, and store images as well as perform image analysis, processing, and interpretation. Using IMAQ Vision, imaging novices and experts can program the most basic or complicated image applications without knowledge of any algorithm implementations.

IMAQ Vision is available for LabVIEW and Measurement Studio, which includes support for LabWindows/CVI, Visual C++, and Visual Basic.

IMAQ Vision Builder

IMAQ Vision Builder is an interactive prototyping tool for machine vision and scientific imaging developers. With IMAQ Vision Builder, you can prototype vision software quickly or test how various vision image processing functions work.

As shown in Figure 1-3, IMAQ Vision Builder generates a Builder file, which is a text description containing a recipe of the machine vision and image processing functions. This Builder file provides a guide you can use for developing applications into any development environment, such as LabWindows/CVI or Visual Basic, using the IMAQ Vision machine vision and image processing libraries. Using the LabVIEW VI creation wizard, you can create a LabVIEW VI that performs the prototype that you created in IMAQ Vision Builder.

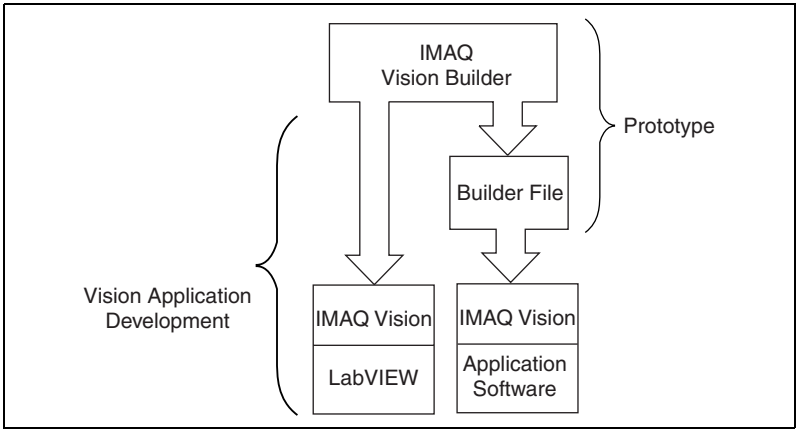


Figure 1-3. IMAQ Vision Builder and Application Development Tools

Integration with DAQ

Any platform that supports NI-IMAQ also supports NI-DAQ and a variety of National Instruments DAQ devices, allowing your IMAQ device and NI-IMAQ development to integrate with National Instruments DAQ products.

Vision and Motion

With National Instruments IMAQ hardware and IMAQ Vision pattern-matching software, you can quickly and accurately locate objects in instances where objects vary in size, orientation, focus, and even when the part is poorly illuminated. Use National Instruments high-performance stepper and servo motion control products with pattern-matching software for inspection and guidance applications, such as locating alignment markers on semiconductor wafers, guiding robotic arms, inspecting the quality of manufactured parts, and locating cells.

2

Installation

This chapter contains a list of necessary and optional items for getting started acquiring images with your IMAQ device. This chapter also explains how to unpack, configure, and install your IMAQ device.

What You Need to Get Started

You need the following items to set up and use the PCI-1428:

- ❑ PCI-1428
- ❑ *Getting Started with Your IMAQ System*
- ❑ *IMAQ PCI-1428 User Manual*
- ❑ *NI-IMAQ Release Notes*
- ❑ NI-IMAQ for Windows 2000/NT/Me/9*x* and documentation
- ❑ Pentium-based PCI computer running Windows XP/2000/Me/NT/9*x*
- ❑ Camera Link camera
- ❑ MDR 26-pin Camera Link cable from 3M
- ❑ Optional software packages and documentation:
  - IMAQ Vision for LabVIEW or Measurement Studio (LabWindows/CVI, Visual C++, Visual Basic)
  - IMAQ Vision Builder
  - LabVIEW
  - Measurement Studio (LabWindows/CVI, tools for Visual Basic)

Optional Equipment

National Instruments offers a variety of products for use with the PCI-1428, including the following:

- MDR 26-pin Camera Link cable from 3M for Base configuration
- IMAQ D6804 breakout cable (for external triggering only)
- RTSI bus cables for connecting the PCI-1428 to other IMAQ, motion control, or DAQ devices
- Other National Instruments DAQ devices for enhanced triggering, timing, or input/output

For more specific information about these products, refer to the National Instruments catalog or Web site, or call the office nearest you.

Setting up Your IMAQ System

Use Figure 2-1 while installing software and hardware, configuring hardware, and using NI-IMAQ in application programs.

Follow the instructions in the *Getting Started with Your IMAQ System* document while installing the NI-IMAQ software and IMAQ hardware.

When accessing the NI-IMAQ device drivers through a programming environment, read the *NI-IMAQ Release Notes* and the *NI-IMAQ User Manual* for help in getting started.

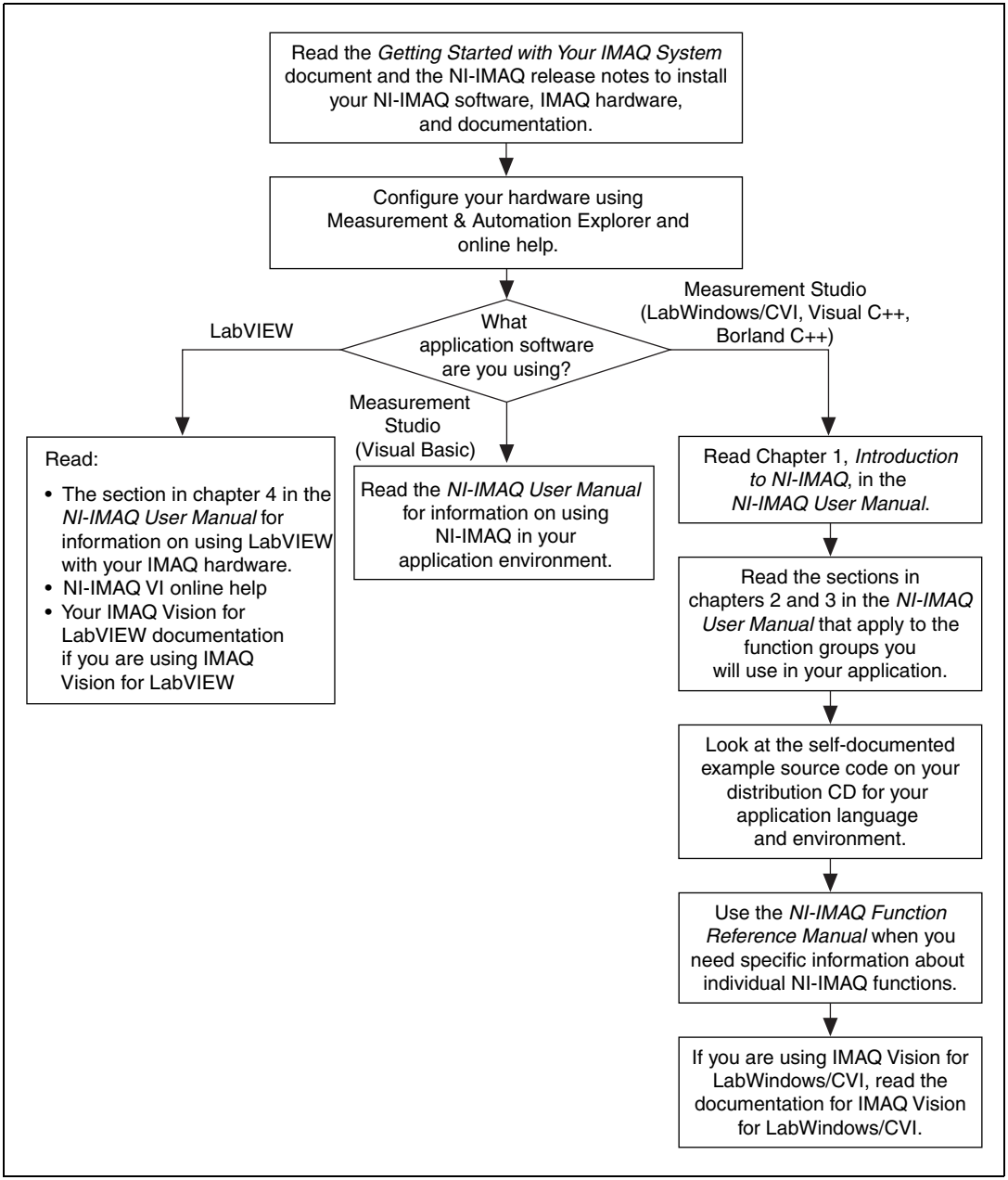

Read the *Getting Started with Your IMAQ System* document and the NI-IMAQ release notes to install your NI-IMAQ software, IMAQ hardware, and documentation.
Configure your hardware using Measurement & Automation Explorer and online help.
What application software are you using?
LabVIEW
Measurement Studio (Visual Basic)
Measurement Studio (LabWindows/CVI, Visual C++, Borland C++)
Read:
• The section in chapter 4 in the *NI-IMAQ User Manual* for information on using LabVIEW with your IMAQ hardware.
• NI-IMAQ VI online help
• Your IMAQ Vision for LabVIEW documentation if you are using IMAQ Vision for LabVIEW
Read the *NI-IMAQ User Manual* for information on using NI-IMAQ in your application environment.
Read Chapter 1, *Introduction to NI-IMAQ*, in the *NI-IMAQ User Manual*.
Read the sections in chapters 2 and 3 in the *NI-IMAQ User Manual* that apply to the function groups you will use in your application.
Look at the self-documented example source code on your distribution CD for your application language and environment.
Use the *NI-IMAQ Function Reference Manual* when you need specific information about individual NI-IMAQ functions.
If you are using IMAQ Vision for LabWindows/CVI, read the documentation for IMAQ Vision for LabWindows/CVI.

Figure 2-1. How to Set up Your IMAQ System

Unpacking

The PCI-1428 ships in an antistatic package to prevent electrostatic discharge from damaging board components. To avoid such damage in handling the board, take the following precautions:

- Ground yourself via a grounding strap or by holding a grounded object, such as your computer chassis.
- Touch the antistatic package to a metal part of your computer chassis before removing the board from the package.
- Remove the board from the package and inspect the board for loose components or any other signs of damage. Notify National Instruments if the board appears damaged in any way. Do *not* install a damaged board in your computer.
- *Never* touch the exposed pins of connectors.

Safety Information

Caution The following paragraphs contain important safety information you *must* follow when installing and operating the device.

Do *not* operate the device in a manner not specified in the documentation. Misuse of the device may result in a hazard and may compromise the safety protection built into the device. If the device is damaged, turn it off and do *not* use it until service-trained personnel can check its safety. If necessary, return the device to National Instruments for repair.

Keep away from live circuits. Do *not* remove equipment covers or shields unless you are trained to do so. If signal wires are connected to the device, hazardous voltages can exist even when the equipment is turned off. To avoid a shock hazard, do *not* perform procedures involving cover or shield removal unless you are qualified to do so. Disconnect all field power prior to removing covers or shields.

If the device is rated for use with hazardous voltages (>30 V_{rms}, 42.4 V_{pk}, or 60 V_{dc}), it may require a safety earth-ground connection wire. See the device specifications for maximum voltage ratings.

Because of the danger of introducing additional hazards, do *not* install unauthorized parts or modify the device. Use the device only with the chassis, modules, accessories, and cables specified in the installation

instructions. All covers and filler panels must be installed while operating the device.

Do *not* operate the device in an explosive atmosphere or where flammable gases or fumes may be present. Operate the device only at or below the pollution degree stated in the specifications. Pollution consists of any foreign matter—solid, liquid, or gas—that may reduce dielectric strength or surface resistivity. Pollution degrees are listed below.

- Pollution Degree 1—No pollution or only dry, nonconductive pollution occurs. The pollution has no effect.
- Pollution Degree 2—Normally only nonconductive pollution occurs. Occasionally, nonconductive pollution becomes conductive because of condensation.
- Pollution Degree 3—Conductive pollution or dry, nonconductive pollution occurs. Nonconductive pollution becomes conductive because of condensation.

Clean the device and accessories by brushing off light dust with a soft, nonmetallic brush. Remove other contaminants with a stiff, nonmetallic brush. The unit *must* be completely dry and free from contaminants before returning it to service.

You *must* insulate signal connections for the maximum voltage for which the device is rated. Do *not* exceed the maximum ratings for the device. Remove power from signal lines before connection to or disconnection from the device.

Operate this device only at or below the installation category stated in the specifications. Installation categories are listed below.

- Installation Category IV—for measurements performed at the source of the low-voltage (<1000 V) installation. Examples include electricity meters, measurements on primary overcurrent protection devices, and ripple-control units.
- Installation Category III—for measurements performed in the building installation. Examples include measurements on distribution boards, circuit-breakers, wiring (including cables), bus bars, junction boxes, switches, socket outlets in the fixed installation, equipment for industrial use, and some other types of equipment, such as stationary motors permanently connected to the fixed installation.
- Installation Category II—for measurements performed on circuits directly connected to the low-voltage installation. Examples include

measurements on household appliances, portable tools, and other similar equipment.

- Installation Category I—for measurements performed on circuits not directly connected to mains[1]. Examples include measurements on circuits not derived from mains, and specially-protected (internal) mains-derived circuits.

Figure 2-1 illustrates a sample installation.

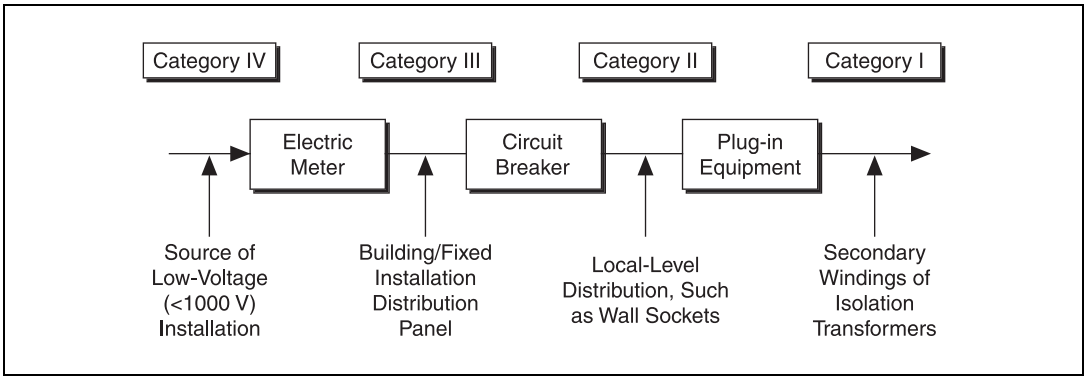


Figure 2-2. Sample Installation

Installation

You can install the PCI-1428 in any available PCI expansion slot in your computer. However, to achieve the best noise performance, leave as much room as possible between the PCI-1428 and other boards and hardware.

Note You must install the NI-IMAQ driver software before installing the 1428 device. For information on how to install NI-IMAQ, see the *Getting Started with Your IMAQ System* document and the *NI-IMAQ Release Notes*.

Use the following guidelines for installing the PCI-1428:

1. Verify that NI-IMAQ is installed on your computer.
2. Turn off and unplug your computer.

Caution To protect yourself and the computer from electrical hazards, the computer should remain off until you finish installing the PCI-1428.

[1] *Mains* is defined as the electricity supply system to which the equipment concerned is designed to be connected for either powering the equipment or for measurement purposes.

3. Follow the electrostatic discharge guidelines in the *Unpacking* section of this chapter.
4. Remove the computer cover.
5. Make sure there are no lit LEDs on the motherboard. If any are lit, wait until they go out before continuing installation.
6. Touch the metal part of the power supply case inside the computer to discharge any static electricity that might be on your clothes or body.
7. Locate the metal bracket that covers the cut-out in the back panel of the chassis for the slot you have selected. Remove and save the bracket-retaining screw and the bracket cover.
8. Line up the PCI-1428 with the MDR 26-pin connector near the cut-out on the computer's back panel. Slowly push down on the top of the PCI-1428 until its card-edge connector is resting on the expansion slot receptacle. Using slow, evenly distributed pressure, press the PCI-1428 straight down until it is evenly positioned in the expansion slot.
9. Reinstall the bracket-retaining screw to secure the PCI-1428 to the back panel rail.
10. Replace the computer cover, and plug the computer in.

Your PCI-1428 is now installed.

Configuring the PCI-1428

Once you have installed the PCI-1428 and powered on your computer, Windows will recognize the device and assign resources to it.

Use MAX to configure the PCI-1428 for acquisition. Refer to the *Interfacing with the PCI-1428* section in Chapter 1, *Introduction*, for further information on using MAX to configure your IMAQ device.

3

Hardware Overview

This chapter provides an overview of PCI-1428 hardware functionality and explains the operations of the device's functional units.

Functional Overview

The PCI-1428 features a flexible, high-speed data path optimized for receiving and formatting video data from Camera Link cameras.

Figure 3-1 illustrates the key functional components of the PCI-1428.

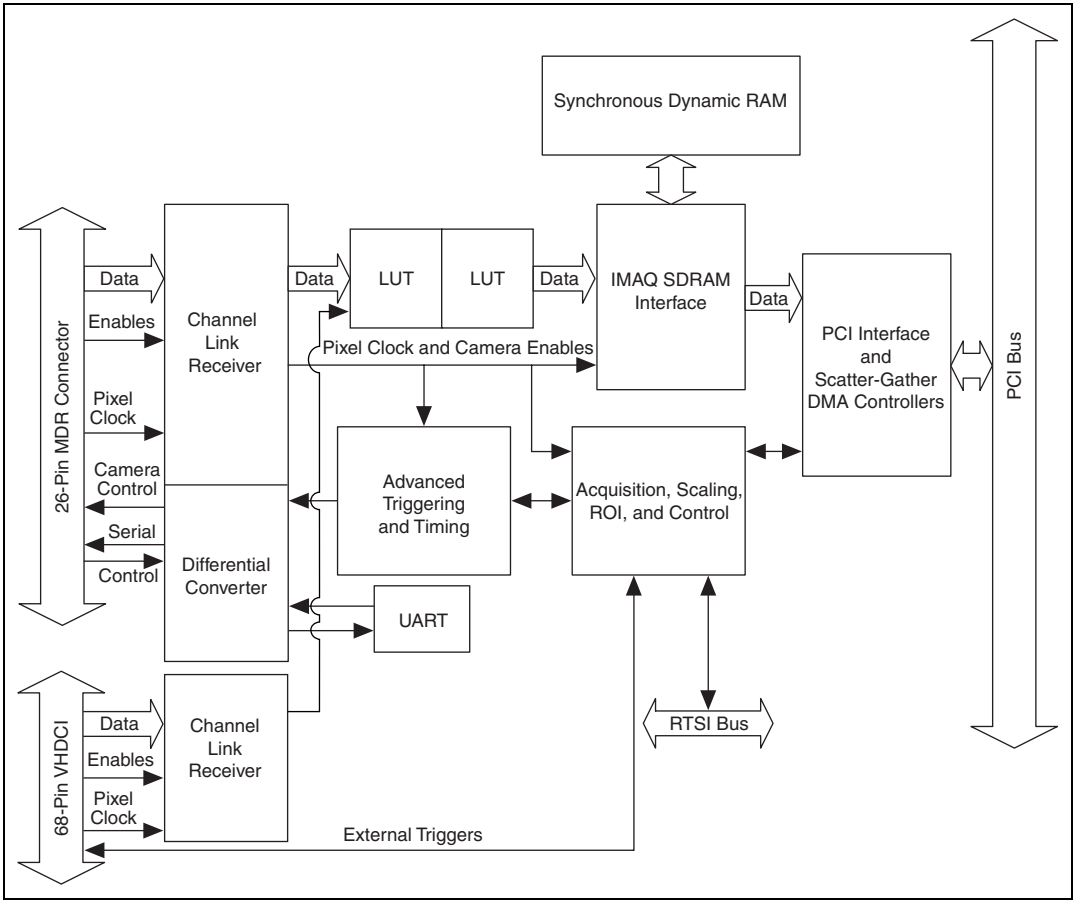


Figure 3-1. PCI-1428 Block Diagram

Camera Link and PCI-1428

The PCI-1428 supports the Camera Link Base configuration, as well as the 8-bit × 4 mode of the Camera Link Medium configuration.

Base Configuration

The Camera Link Base configuration places 24 data bits and four enable signals (Frame Valid, Line Valid, Data Valid, and a spare) on a single Channel Link part and cable.

The Base configuration includes asynchronous serial transmission as well as four digital camera control lines for controlling exposure time, frame rates, and other camera control signals. These four control lines are

configured in the camera file to generate precise timing signals for controlling digital camera acquisition.

Base configuration includes the following bit allocations:

- 8-bit × 1, 2, and 3 taps (channels)
- 10-bit × 1 and 2 taps
- 12-bit × 1 and 2 taps
- 14-bit × 1 tap
- 16-bit × 1 tap
- 24-bit RGB

Medium Configuration

The PCI-1428 supports the 8-bit × 4 tap of the Camera Link Medium configuration. The Medium configuration requires using both connectors. This configuration allows for more data throughput by offering two synchronized data streams between the camera and the PCI-1428.

Data Transmission

A 28-to-4 serializing Channel Link chip drives the data and camera enable signals across the Camera Link cable, and the camera's pixel clock controls the Channel Link's data transmission. The four LVDS pairs are then deserialized by another Channel Link chip on the PCI-1428.

Note Exact timing of camera and image acquisition device communication is camera dependent. The *Specifications of the Camera Link Interface Standard for Digital Cameras and Frame Grabbers* manual fully explains the Camera Link timing requirements.

LUTs

The PCI-1428 offers two 64 KB × 16-bit lookup tables (LUTs) that can perform up to four 256 KB × 8-bit LUT operations, such as contrast enhancement, data inversion, gamma manipulation, or other nonlinear transfer functions.

Multiple-Tap Data Formatter

Many digital cameras transfer multiple taps, or channels, of data simultaneously to increase the frame rate of the camera. However, the data in each tap may not be transferred in the traditional top-left to bottom-right direction. Also, the taps may not transfer data in the same direction.

The multiple-tap data formatting circuitry on the PCI-1428 can reorder the data from up to four taps. The data from each tap can be independently scanned either from left-to-right or right-to-left and top-to-bottom or bottom-to-top.

Note For your convenience, data reformatting instructions for these cameras have been preprogrammed into the camera files.

SDRAM

The PCI-1428 has 16 MB of onboard high-speed synchronous dynamic RAM (SDRAM). The PCI-1428 uses the onboard RAM as a FIFO buffer to ensure acquisition. Even when the data rate from the camera exceeds PCI throughput, you can acquire without interruption until the onboard RAM is full.

Trigger Control and Mapping Circuitry

The trigger control and mapping circuitry routes, monitors, and drives the external and RTSI bus trigger lines. You can configure each line to start an acquisition on a rising or falling edge and drive each line asserted or unasserted, much like a digital I/O line. You can also map pulses from the high-speed timing circuitry or many of the PCI-1428 status signals to these trigger lines. Four external and four RTSI bus triggers (all of which are programmable for polarity and direction) are available for simultaneous use.

High-Speed Timing

Built from high-speed counters, the high-speed timing circuitry on the PCI-1428 can generate precise real-time control signals for your camera. Map the output of this circuitry to a trigger line to provide accurate pulses and pulse trains. Use these control signals to control exposure time and frame rate.

Note For your convenience, the external control for cameras that support it has been preprogrammed into the camera file. You can use MAX to specify the frequency and

duration of these signals in easy-to-use units. See the *Interfacing with the PCI-1428* section in Chapter 1, *Introduction*, for information on camera files.

Acquisition, Scaling, ROI

The acquisition, scaling, and region-of-interest (ROI) circuitry monitors incoming video signals and routes the active pixels to the multiple-tap data formatter and SDRAM. The PCI-1428 can perform ROI and scaling on all video lines and frames. Pixel and line scaling transfers multiples of two, four, or eight pixels and lines to onboard memory. In an ROI acquisition, select an area within the acquisition window to transfer across the PCI bus to system memory.

Note You can use MAX to set the acquisition, scaling, and ROI parameters.

Scatter-Gather DMA Controllers

The PCI-1428 uses three independent onboard direct memory access (DMA) controllers. The DMA controllers transfer data between the onboard SDRAM memory buffers and the PCI bus. Each of these controllers supports scatter-gather DMA, which allows the DMA controller to reconfigure on the fly. The PCI-1428 can perform continuous image transfers directly to either contiguous or fragmented memory buffers.

Bus Master PCI Interface

The PCI-1428 implements the PCI interface with a National Instruments custom application-specific integrated circuit (ASIC), the PCI MITE. The PCI interface can transfer data at a maximum rate of 133 MB/s in bus master mode.

Start Conditions

The PCI-1428 can start acquisitions in the following ways:

- Software control—The PCI-1428 supports software control of acquisition start. You can configure the PCI-1428 to capture a fixed number of frames. This configuration is useful for capturing a single frame or a sequence of frames.
- Trigger control—You can start an acquisition by enabling external or RTSI bus trigger lines. Each of these inputs can start a video acquisition on a rising or falling edge. You can use all four external triggers and up to four RTSI bus triggers simultaneously.

- Delayed acquisition—Use either software or triggers to start acquisitions instantaneously or after skipping a specific number of frames. You can use delayed acquisition for post-trigger applications.

Acquisition Window Control

You can configure the following parameters on the PCI-1428 to control the video acquisition window:

- Acquisition window—The PCI-1428 allows the user to specify a particular region of active pixels and active lines within the incoming video data. The active pixel region selects the starting pixel and number of pixels to be acquired relative to the assertion edge of the horizontal (or line) enable signal from the camera. The active line region selects the starting line and number of lines to be acquired relative to the assertion edge of the vertical (or frame) enable signal.
- Region of interest—The PCI-1428 uses a second level of active pixel and active line regions for selecting a region of interest. Using the region-of-interest circuitry, the device acquires only a selected subset of the acquisition window.
- Scaling down—The scaling-down circuitry also controls the active acquisition region. The PCI-1428 can scale down a frame by reducing the number of pixels per line, the number of lines per frame, or both. For active pixel selection, the PCI-1428 selects every pixel, every other pixel, every fourth pixel, or every eighth pixel. For active line selection, the PCI-1428 selects every line, every other line, every fourth line, or every eighth line. You can use the scaling-down circuitry in conjunction with the region-of-interest circuitry.

Serial Interface

The PCI-1428 provides serial connections to and from the camera through two LVDS pairs in the Camera Link cable. All Camera Link serial communication uses one start bit, one stop bit, no parity, and no hardware handshaking.

The PCI-1428 supports the following baud rates: 56000, 38400, 19200, 9600, 7200, 4800, 3600, 2400, 2000, 1800, 1200, 600, and 300.

You can use the serial interface interactively with MAX and `clsercon.exe`, or programmatically with LabVIEW and C.

Interactively:

- MAX—Use MAX with a camera file containing preprogrammed commands. When an acquisition is initiated, the commands are sent to the camera.
- `clsercon.exe`—Use National Instruments terminal emulator for Camera Link, `clsercon.exe`, if a camera file with preprogrammed serial commands does not exist for your camera. With `clsercon.exe`, you can still communicate serially with your camera. Go to `<NI-IMAQ>/bin` to access `clsercon.exe`.

Programmatically:

- LabVIEW—Use the serial interface programmatically, through calls to the NI-IMAQ driver using the IMAQ Serial Write and IMAQ Serial Read VIs. Go to `<LabVIEW>/vi.lib/vision/driver/imaqll.llb` to access these files.
- C—Use the serial interface programmatically, through calls to the NI-IMAQ driver using `imgSessionSerialWrite` and `imgSessionSerialRead`.

Note `clsercon.exe`, IMAQ Serial Write, IMAQ Serial Read, `imgSessionSerialWrite`, and `imgSessionSerialRead` are used for directly accessing the PCI-1428 serial port and are not required for most users.

National Instruments also fully supports the recommended serial API described in the *Specifications of the Camera Link Interface Standard for Digital Cameras and Frame Grabbers* manual.

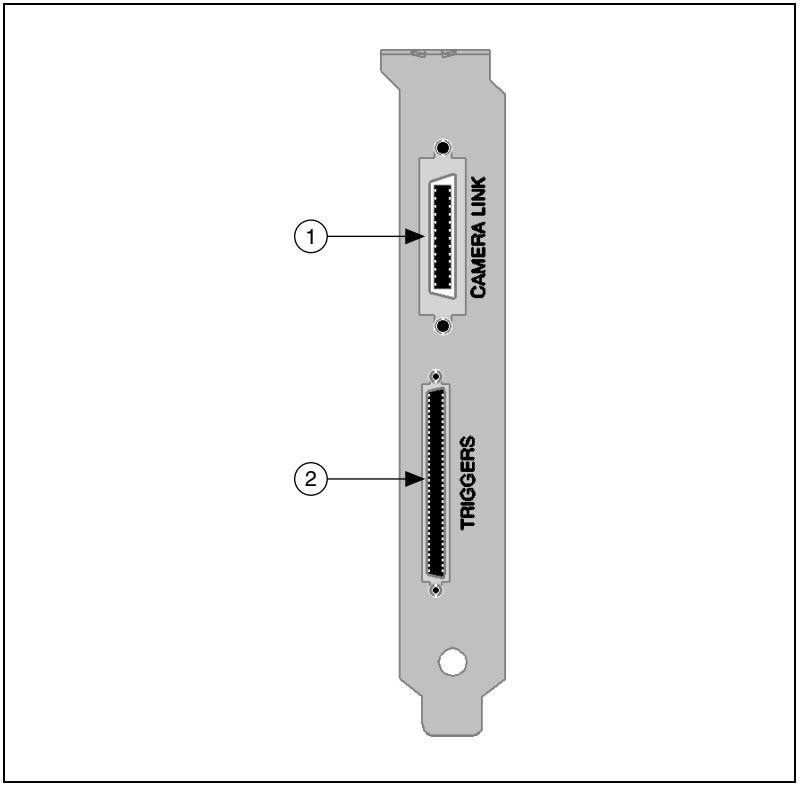
4

Signal Connections

This chapter describes the MDR 26-pin connector and the 68-pin VHDCI connector on the PCI-1428 device.

Connectors

Figure 4-1 shows the connectors on the PCI-1428 device.



1	MDR 26-Pin Connector	2	68-Pin VHDCI Connector

Figure 4-1. PCI-1428 Connectors

MDR 26-Pin Connector

The MDR 26-pin connector provides reliable high-frequency transfer rates between the camera and the acquisition device. To access this connector, use a 3M Camera Link cable. For additional information on Camera Link cables, including ordering information and cable lengths, see the *Camera Link Cables* section in Appendix B, *Cabling*.

Figure 4-2 shows the PCI-1428 MDR 26-pin connector assignments. See Table 4-1 for a description of the MDR-26 and 68-pin VHDCI signal connections.

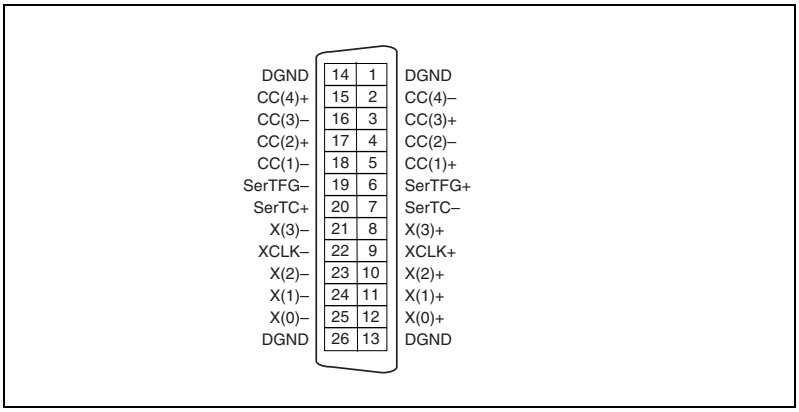

DGND 14 1 DGND
CC(4)+ 15 2 CC(4)–
CC(3)– 16 3 CC(3)+
CC(2)+ 17 4 CC(2)–
CC(1)– 18 5 CC(1)+
SerTFG– 19 6 SerTFG+
SerTC+ 20 7 SerTC–
X(3)– 21 8 X(3)+
XCLK– 22 9 XCLK+
X(2)– 23 10 X(2)+
X(1)– 24 11 X(1)+
X(0)– 25 12 X(0)+
DGND 26 13 DGND

Figure 4-2. MDR 26-Pin Connector Assignments

68-Pin VHDCI Connector

The 68-pin VHDCI connector connects to external digital I/O lines and triggers. To access these connections, build a custom cable or use an optional cable from National Instruments. For information on building a custom cable for the 68-pin VHDCI connector, see the *68-Pin VHDCI Cable Specification* section in Appendix B, *Cabling*.

Figure 4-3 shows the 68-pin VHDCI connector pinout. See Table 4-1 for a description of the MDR-26 and 68-pin VHDCI signal connections.

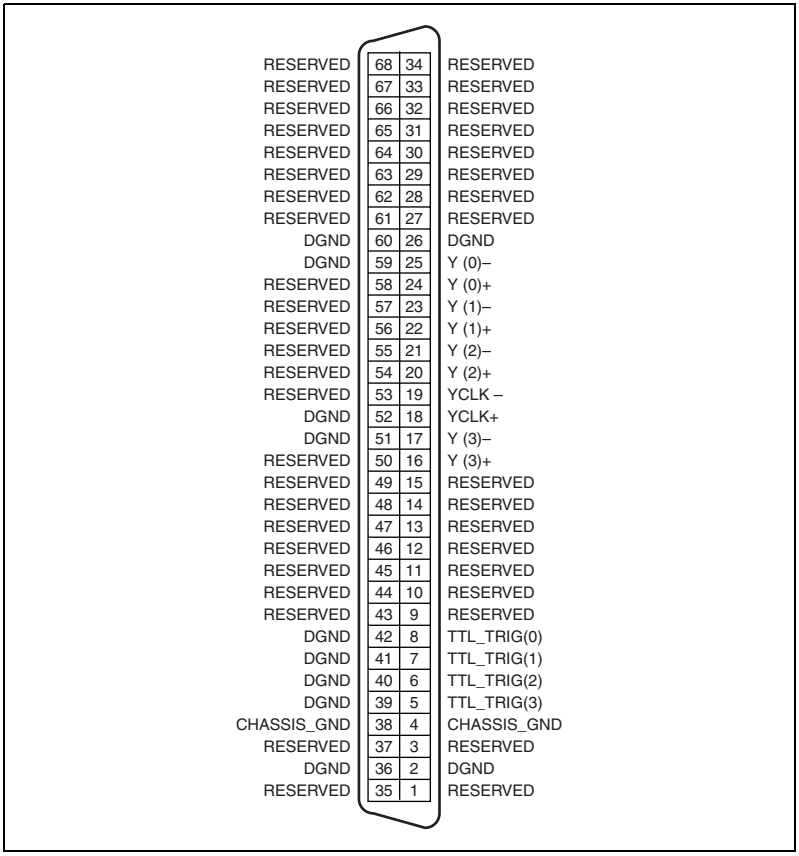

RESERVED 68 34 RESERVED
RESERVED 67 33 RESERVED
RESERVED 66 32 RESERVED
RESERVED 65 31 RESERVED
RESERVED 64 30 RESERVED
RESERVED 63 29 RESERVED
RESERVED 62 28 RESERVED
RESERVED 61 27 RESERVED
DGND 60 26 DGND
DGND 59 25 Y (0)–
RESERVED 58 24 Y (0)+
RESERVED 57 23 Y (1)–
RESERVED 56 22 Y (1)+
RESERVED 55 21 Y (2)–
RESERVED 54 20 Y (2)+
RESERVED 53 19 YCLK –
DGND 52 18 YCLK+
DGND 51 17 Y (3)–
RESERVED 50 16 Y (3)+
RESERVED 49 15 RESERVED
RESERVED 48 14 RESERVED
RESERVED 47 13 RESERVED
RESERVED 46 12 RESERVED
RESERVED 45 11 RESERVED
RESERVED 44 10 RESERVED
RESERVED 43 9 RESERVED
DGND 42 8 TTL_TRIG(0)
DGND 41 7 TTL_TRIG(1)
DGND 40 6 TTL_TRIG(2)
DGND 39 5 TTL_TRIG(3)
CHASSIS_GND 38 4 CHASSIS_GND
RESERVED 37 3 RESERVED
DGND 36 2 DGND
RESERVED 35 1 RESERVED

Figure 4-3. 68-Pin VHDCI Connector Pin Assignments

Connector Signal Connection Descriptions

Table 4-1 describes the MDR-26 and 68-pin VHDCI signal connections.

Table 4-1. I/O Connector Signals

Signal Name	Description
TTL_TRIG	TTL external triggers/DIO lines (input/output)
DGND	A direct connection to digital GND on the 1428 device
CHASSIS_GND	A direct connection to the computer's chassis, which is grounded through the power cord
X<3..0>±	LVDS Base configuration data and enable signals from the acquisition device to the camera

Table 4-1. I/O Connector Signals (Continued)

Signal Name	Description
Y<3..0>±	LVDS Medium configuration data and enable signals from the acquisition device to the camera
XCLK±	Transmission clock on the Base configuration chip for Camera Link communication between the acquisition device and the camera
YCLK±	Transmission clock on the Medium configuration chip for Camera Link communication between the acquisition device and the camera
SerTC±	Serial transmission to the camera from the image acquisition device
SerTFG±	Serial transmission to the frame grabber from the camera
CC<4..1>±	Four LVDS pairs (defined as camera inputs and acquisition device outputs) reserved for camera control On some cameras, the camera controls allow the acquisition device to control exposure time and frame rate.

A

Specifications

This appendix lists the specifications of the PCI-1428. These specifications are typical at 25 °C, unless otherwise stated.

External Connections

Trigger sense ..... TTL

Trigger level ..... Programmable (rising or falling)

Pixel clock ..... Camera Link compatible

Enables ..... Camera Link compatible

Control signal ..... Camera Link compatible

Video data ..... Camera Link compatible

Clocks

Pixel clock frequency range ..... 20 to 50 MHz

Note Camera Link cameras must transmit at a minimum of 20 MHz.[1]

PCI Interface

PCI initiator (master) capability ..... Supported

PCI target (slave) capability ..... Supported

Data path ..... 32 bits

Card type ..... 32-bit half-size card

Parity generation/checking,
error reporting ..... Supported

[1] This value corresponds to the post-serialization Camera Link cable transmission rate of 140 to 350 MHz.

Target decode speed .....Medium (1 clock)

Target fast back-to-back capability .....Supported

PCI master performance

Ideal .....133 MB/s

Sustained.....100 MB/s

Power Requirements

Voltage.....+5 VDC (1.5 ADC)
+12 VDC (24 mA)
–12 VDC (20 mA)

Physical

Dimensions .....10.7 by 17.5 cm
(4.2 by 6.9 in.)

Weight .....0.127 kg (0.28 lb)

Environment

Operating temperature ..... 0 to 55 °C

Storage temperature.....–20 to 70 °C

Relative humidity .....5 to 90%, noncondensing

Emissions.....EN 55011:1991 Group 1 Class A
at 10 m FCC Class A at 10 m

B

Cabling

This appendix contains cabling requirements for the PCI-1428, including Camera Link cable ordering information.

68-Pin VHDCI Cable Specification

National Instruments offers cables and accessories for connecting to video sources, trigger sources, or synchronization sources. However, if you want to develop your own cable for the 68-pin VHDCI connector, you must use twisted pairs for each signal.

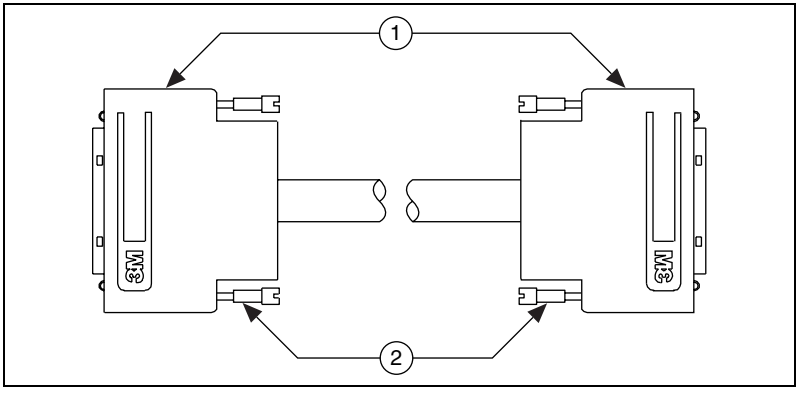
For information on connector pin assignments, see the *Connectors* section in Chapter 4, *Signal Connections*.

Camera Link Cables

Use a 3M Camera Link cable or build your own cable (not recommended) to connect your camera to the MDR 26-pin connector on the PCI-1428 device. Camera Link cables consist of two MDR-26 male plugs linked with a twin-axial shielded cable and are available in two shell configurations.

For more information on Camera Link cables, reference the *Specifications of the Camera Link Interface Standard for Digital Cameras and Frame Grabbers* manual. This manual is available on several Web sites, including the Automated Imaging Association site at `machinevisiononline.org`.

Figure B-1 illustrates the Camera Link cable.



1	MDR 26-Pin Male Plug	2	2X Thumbscrews

Figure B-1. Camera Link Cable

Ordering Information

Camera Link cables are manufactured by 3M corporation and are available from both National Instruments and 3M.

Two-meter Camera Link cables (part number 187676-02) are available from the National Instruments Web site at `ni.com/catalog`. Camera Link cables are available in 1 to 10 m lengths from the 3M Web site at `3m.com`. See Figure B-2 for 3M part number information.

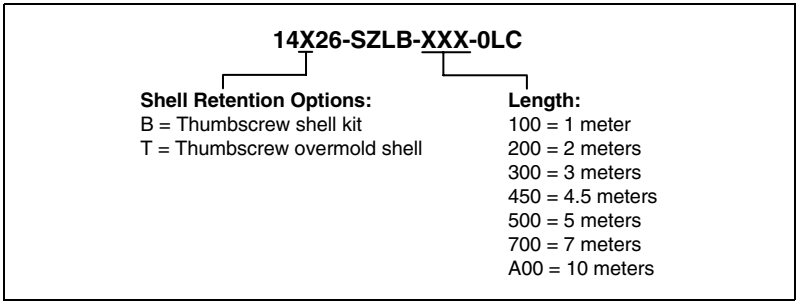


Figure B-2. 3M Part Number Ordering Information

C

Technical Support Resources

Web Support

National Instruments Web support is your first stop for help in solving installation, configuration, and application problems and questions. Online problem-solving and diagnostic resources include frequently asked questions, knowledge bases, product-specific troubleshooting wizards, manuals, drivers, software updates, and more. Web support is available through the Technical Support section of `ni.com`.

NI Developer Zone

The NI Developer Zone at `ni.com/zone` is the essential resource for building measurement and automation systems. At the NI Developer Zone, you can easily access the latest example programs, system configurators, tutorials, technical news, as well as a community of developers ready to share their own techniques.

Customer Education

National Instruments provides a number of alternatives to satisfy your training needs, from self-paced tutorials, videos, and interactive CDs to instructor-led hands-on courses at locations around the world. Visit the Customer Education section of `ni.com` for online course schedules, syllabi, training centers, and class registration.

System Integration

If you have time constraints, limited in-house technical resources, or other dilemmas, you may prefer to employ consulting or system integration services. You can rely on the expertise available through our worldwide network of Alliance Program members. To find out more about our Alliance system integration solutions, visit the System Integration section of `ni.com`.

Worldwide Support

National Instruments has offices located around the world to help address your support needs. You can access our branch office Web sites from the Worldwide Offices section of `ni.com`. Branch office Web sites provide up-to-date contact information, support phone numbers, e-mail addresses, and current events.

If you have searched the technical support resources on our Web site and still cannot find the answers you need, contact your local office or National Instruments corporate. Phone numbers for our worldwide offices are listed at the front of this manual.

Glossary

Prefix	Meaning	Value
k-	kilo-	10^3
M-	mega-	10^6

Numbers/Symbols

%	Percent.
+	Positive of, or plus.
/	Per.
Ω	Ohm.
±	Plus or minus.
–	Negative of, or minus.

A

A	Amperes.
AC	Alternating current.
acquisition window	The image size specific to a video standard or camera resolution.
active line region	The region of lines actively being stored. Defined by a line start (relative to the vertical synchronization signal) and a line count.
active pixel region	The region of pixels actively being stored. Defined by a pixel start (relative to the horizontal synchronization signal) and a pixel count.
address	Value that identifies a specific location (or series of locations) in memory.
ANSI	American National Standards Institute.

API	Application programming interface.
area	A rectangular portion of an acquisition window or frame that is controlled and defined by software.
array	Ordered, indexed set of data elements of the same type.
ASIC	Application-Specific Integrated Circuit. A proprietary semiconductor component designed and manufactured to perform a set of specific functions for specific customer needs.

B

b	Bit. One binary digit, either 0 or 1.
B	Byte. Eight related bits of data, an eight-bit binary number; also used to denote the amount of memory required to store one byte of data
buffer	Temporary storage for acquired data.
bus	A group of conductors that interconnect individual circuitry in a computer, such as the PCI bus; typically the expansion vehicle to which I/O or other devices are connected.

C

C	Celsius.
cache	High-speed processor memory that buffers commonly used instructions or data to increase processing throughput.
Camera Link	Interface standard for digital video data and camera control based on the Channel Link chipset.
Channel Link	National Semiconductor chipset for high-speed data serialization and deserialization for transmission across cables up to 10 m.
CMOS	Complementary metal-oxide semiconductor.
CPU	Central processing unit.

D

DAQ	Data acquisition. (1) Collecting and measuring electrical signals from sensors, transducers, and test probes or fixtures and inputting them to a computer for processing. (2) Collecting and measuring the same kinds of electrical signals with A/D or DIO boards plugged into a computer, and possibly generating control signals with D/A and/or DIO boards in the same computer.
DC	Direct current.
default setting	A default parameter value recorded in the driver; in many cases, the default input of a control is a certain value (often 0) that means *use the current default setting.*
DMA	Direct memory access. A method by which data can be transferred to and from computer memory from and to a device or memory on the bus while the processor does something else; DMA is the fastest method of transferring data to/from computer memory.
DRAM	Dynamic RAM.
drivers	Software that controls a specific hardware device, such as an image acquisition board.
dynamic range	The ratio of the largest signal level a circuit can handle to the smallest signal level it can handle (usually taken to be the noise level), normally expressed in decibels.

E

EEPROM	Electrically erasable programmable read-only memory. ROM that can be erased with an electrical signal and reprogrammed.
external trigger	A voltage pulse from an external source that triggers an event such as A/D conversion.

F

FIFO	First-in first-out memory buffer. The first data stored is the first data sent to the acceptor; FIFOs are used on IMAQ devices to temporarily store incoming data until that data can be retrieved.
ft	Feet.

H

h	Hour.
Hz	Hertz. Frequency in units of one cycle per second.

I

I/O	Input/output. The transfer of data to/from a computer system involving communications channels, operator interface devices, and/or data acquisition and control interfaces.
IC	Integrated circuit.
IEEE	Institute of Electrical and Electronics Engineers.
in.	Inches.
instrument driver	A set of high-level software functions, such as NI-IMAQ, that control specific plug-in computer boards. Instrument drivers are available in several forms, ranging from a function callable from a programming language to a virtual instrument (VI) in LabVIEW.
interrupt	A computer signal indicating that the CPU should suspend its current task to service a designated activity.
interrupt level	The relative priority at which a device can interrupt.
IRQ	Interrupt request. *See* interrupt.

K

k	Kilo. The standard metric prefix for 1,000, or 10^3, used with units of measure such as volts, hertz, and meters.
K	Kilo. The prefix for 1,024, or 2^{10}, used with B in quantifying data or computer memory.
kbytes/s	A unit for data transfer that means 1,000 or 10^3 bytes/s.
Kword	1,024 words of memory.

L

line count	The total number of horizontal lines in the picture.
LSB	Least significant bit.
LUT	Look-up table. Table containing values used to transform the gray-level values of an image. For each gray-level value in the image, the corresponding new value is obtained from the look-up table.
LVDS	Low Voltage Differential Signaling (EIA-644).

M

m	Meters.
M	(1) Mega, the standard metric prefix for 1 million or 10^6, when used with units of measure such as volts and hertz; (2) mega, the prefix for 1,048,576, or 2^{20}, when used with B to quantify data or computer memory.
MB	Megabyte of memory.
Mbytes/s	A unit for data transfer that means 1 million or 10^6 bytes/s.
memory buffer	*See* buffer.
memory window	Continuous blocks of memory that can be accessed quickly by changing addresses on the local processor.

MSB	Most significant bit.
MTBF	Mean time between failure.
mux	Multiplexer. A switching device with multiple inputs that selectively connects one of its inputs to its output.

N

NI-IMAQ	Driver software for National Instruments IMAQ hardware.
NVRAM	Nonvolatile RAM. RAM that is not erased when a device loses power or is turned off.

O

operating system	Base-level software that controls a computer, runs programs, interacts with users, and communicates with installed hardware or peripheral devices.

P

PCI	Peripheral Component Interconnect. A high-performance expansion bus architecture originally developed by Intel to replace ISA and EISA. PCI offers a theoretical maximum transfer rate of 132 Mbytes/s.
pixel	Picture element. The smallest division that makes up the video scan line; for display on a computer monitor, a pixel's optimum dimension is square (aspect ratio of 1:1, or the width equal to the height).
pixel clock	Divides the incoming horizontal video line into pixels.
pixel count	The total number of pixels between two horizontal synchronization signals. The pixel count determines the frequency of the pixel clock.
protocol	The exact sequence of bits, characters, and control codes used to transfer data between computers and peripherals through a communications channel.
pts	Points.

R

RAM	Random-access memory.
real time	A property of an event or system in which data is processed as it is acquired instead of being accumulated and processed at a later time.
relative accuracy	A measure in LSB of the accuracy of an ADC; it includes all nonlinearity and quantization errors but does not include offset and gain errors of the circuitry feeding the ADC.
resolution	The smallest signal increment that can be detected by a measurement system. Resolution can be expressed in bits, in proportions, or in percent of full scale. For example, a system has 12-bit resolution, one part in 4,096 resolution, and 0.0244 percent of full scale.
RGB	Color encoding scheme using red, green, and blue (RGB) color information where each pixel in the color image is encoded using 32 bits: 8 bits for red, 8 bits for green, 8 bits for blue, and 8 bits for the alpha value (unused).
ribbon cable	A flat cable in which the conductors are side by side.
ROI	Region of interest. A hardware-programmable rectangular portion of the acquisition window.
ROM	Read-only memory.
RTSI bus	Real-Time System Integration Bus. The National Instruments timing bus that connects IMAQ and DAQ boards directly, by means of connectors on top of the boards, for precise synchronization of functions.

S

s	Seconds.
saturation	The amount of white added to a pure color. Saturation relates to the richness of a color. A saturation of zero corresponds to a pure color with no white added. Pink is a red with low saturation.
scaling down circuitry	Circuitry that scales down the resolution of a video signal.
scatter-gather DMA	A type of DMA that allows the DMA controller to reconfigure on-the-fly.
SDRAM	Synchronous dynamic RAM.

SRAM	Static RAM.
sync	Tells the display where to put a video picture. The horizontal sync indicates the picture's left-to-right placement and the vertical sync indicates top-to-bottom placement.
system RAM	RAM installed on a personal computer and used by the operating system, as contrasted with onboard RAM.

T

tap	A stream of pixels from a camera. Some cameras send multiple streams, or taps, of data over a cable simultaneously to increase transfer rate.
transfer rate	The rate, measured in bytes/s, at which data is moved from source to destination after software initialization and set up operations. The maximum rate at which the hardware can operate.
trigger	Any event that causes or starts some form of data capture.
trigger control and mapping circuitry	Circuitry that routes, monitors, and drives external and RTSI bus trigger lines. You can configure each of these lines to start or stop acquisition on a rising or falling edge.
TTL	Transistor-transistor logic.

V

VI	Virtual Instrument. (1) A combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument (2) A LabVIEW software module (VI), which consists of a front panel user interface and a block diagram program.

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